Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia

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This paper estimates the productivity gains from reducing tariffs on final goods and from reducing tariffs on intermediate inputs. Lower output tariffs can increase productivity by inducing tougher import competition, whereas cheaper imported inputs can raise productivity via learning, variety, and quality effects. We use Indonesian manufacturing census data from 1991 to 2001, which include plant-level information on imported inputs. The results show that a 10 percentage point fall in input tariffs leads to a productivity gain of 12 percent for firms that import their inputs, at least twice as high as any gains from reducing output tariffs. (*JEL* F12, F13, L16, O14, O19, O24)

The effects of trade reform on productivity have been widely studied, but there remains a gap in this literature. Theoretical models analyze the effects of reducing tariffs on both final goods and intermediate inputs on productivity. Empirical studies have focused primarily, however, on the effects of reducing tariffs on final goods. Reducing output tariffs can produce productivity gains by inducing tougher import competition, whereas cheaper imported inputs can raise productivity via learning, variety, and quality effects. Although a fall in a tariff on inputs such as compressors may force the domestic compressor industry to become more competitive, it has quite different effects on users of these inputs, such as producers of refrigerators. Their productivity can increase due to the foreign technology embodied in those inputs.[1]

Using Indonesian data, this paper disentangles the productivity gains that arise from reducing tariffs on final goods from those that arise from reducing tariffs on intermediate inputs. Further, we estimate the differential productivity effect from the reduction in input tariffs on firms that import these inputs to those firms that compete with them. This is possible, as one of the unique features of the Indonesian dataset is that it provides information on the proportion of imported inputs at the plant level.

Our main data source is an annual manufacturing census of all firms with 20 or more employees for the years 1991 to 2001.[2] Each census comprises information on output, employment,

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[1] One of the principal opponents to the North American Free Trade Agreement (NAFTA) was a Mexican refrigerator manufacturer who was concerned that he would be driven out of business by US competition. The refrigerators were of such poor quality that they did not last very long due to the use of flawed domestically produced compressors. Following NAFTA, this manufacturer was able to obtain higher-quality American compressors and became one of the largest suppliers of refrigerators to the US market. See Anne O. Krueger (2004).

[2] There may be some skepticism about the reliability of micro-level data from a developing country with a high level of corruption. Lisa A. Cameron and Vivi Alatas (2003) found that these data produced a wage distribution similar to that for formal sector workers in the most commonly used source of Indonesian wage data, the Labor Force Survey (*Sakernas*). Furthermore, the data are consistent

Table 1—Tariffs in Indonesia, 1991–2001

Industry	Tariff type	1991	1993	1995	1997	1999	2001
31 food	output	20.84	20.50	20.62	19.19	15.95	15.94
	input	13.86	13.60	9.83	8.68	7.12	6.95
32 textile clothing	output	27.35	26.65	20.19	16.53	12.68	9.43
	input	17.59	17.38	13.25	10.76	8.87	6.27
33 wood	output	24.20	24.10	17.95	12.32	9.43	6.91
	input	10.24	10.09	6.52	4.32	3.57	2.90
34 paper	output	21.21	19.76	10.09	7.04	4.31	4.03
	input	17.56	16.30	9.42	6.86	4.81	4.18
35 chemicals	output	15.60	14.93	12.05	10.11	8.31	6.92
	input	11.14	11.05	9.00	7.57	6.26	5.16
36 metal	output	23.04	21.84	10.62	7.46	6.40	5.65
	input	14.81	13.94	9.52	7.95	6.61	5.64
37 machinery	output	11.50	9.72	8.08	7.32	6.85	5.77
	input	9.80	9.94	7.82	7.32	6.88	6.15
38 electrical	output	18.89	18.56	14.69	11.01	7.75	6.69
	input	13.84	13.53	10.25	8.32	7.26	6.26
39 other	output	32.50	31.57	22.11	17.70	14.28	10.98
	input	15.94	15.37	11.25	9.17	7.67	6.17
All	output	20.88	20.29	15.58	12.51	9.76	8.44
	input	13.71	13.40	9.92	8.24	6.91	5.94

ownership, exports, and imports. The input tariffs are constructed as a weighted average of the output tariffs, where the weights are based on cost shares for nearly three hundred industries. For example, if an industry uses 70 percent steel and 30 percent rubber, the input tariff for that industry is equal to 70 percent of the steel tariff plus 30 percent of the rubber tariff. Rather than relying on aggregate input/output tables for these weights, we use plant-level details of every input used in the production process for 1998 (the only year these data were available), and assume constant technology over the sample period. The data show there are wide disparities in tariffs along the production chain, generally exhibiting an escalating structure with lower tariffs on inputs and higher tariffs on final goods. For example, tariffs are 0 percent on motor vehicle bodies, 11 percent on motor vehicle components, and 31.6 percent on motor vehicles.[3] The largest tariff reductions in Indonesia over our sample period began in 1995 with the World Trade Organization (WTO) commitment to reduce all bound tariffs to 40 percent or less.[4] Final goods tariffs fell from an average of 21 percent in 1991 to an average of 8 percent in 2001, with large variations across and within industries (see Table 1). Some tariffs are still as high as 170 percent. Given the large variation in tariffs along the production chain and between industries, it is essential to have a high level of disaggregation for this kind of study.

We estimate production functions at the three-digit level (29 industries) using the Olley-Pakes methodology (G. Steven Olley and Ariel Pakes 1996) to correct for simultaneity in the choice of inputs and firm exit. We modify their approach to control also for the simultaneity between productivity shocks and the decision to import intermediate inputs, as well as the simultaneity between productivity shocks and the decision to export, as in Hiroyuki Kasahara and Joel

across the whole sample period, thus increasing confidence in their reliability.

[3] These rates are for 2001 for International Standard of Industrial Classification of All Economic Activities (ISIC) codes 38432, 38433, and 38431, respectively. This escalating tariff structure is typical in many countries. See www.worldbank.org/trade.

[4] See General Agreement on Tariffs and Trade (GATT) (1994). A bound tariff provides an upper bound for tariffs that can be imposed on a member of the WTO. It is a commitment given by a country under GATT/WTO negotiations not to increase tariffs on products originating in WTO member countries beyond the bound tariff. Given the high level of corruption in Indonesia, there might be concern that the tariff reform process has been driven by politically connected firms. However, Ahmed M. Mobarak and Denni Purbasari (2005) find that political connections in Indonesia did not affect tariff rates.

Rodrigue (2005), Johannes Van Biesebroeck (2005), and Jan De Loecker (2006). We also take account of the Asian financial crisis in 1997 and 1998. Then we regress productivity at the plant level on final goods tariffs and input tariffs at the five-digit ISIC level (288 industries). To see whether trade liberalization has a larger effect on importing firms, we interact the input tariffs with importing firms.

The results show that the largest productivity gains arise from reducing input tariffs: a 10 percentage point fall in input tariffs leads to a 12 percent productivity gain for importing firms, at least twice as high as any gains from reducing output tariffs. The productivity gains associated with a 10 percentage point fall in output tariffs range between 1 and 6 percent, depending on the estimation techniques. These gains are likely due to tougher import competition. Interestingly, when we regress productivity only on final goods tariffs, as is common in the literature, the effect is more than doubled using the OLS estimates. This suggests that excluding input tariffs could lead to an omitted variable problem, overestimating the "import-competition" effect and perhaps underestimating the total effect.

The coefficient on input tariffs for importing firms is significant and robust across all specifications, including controls for the Asian crisis period. The larger impact for importing firms than for nonimporting firms is suggestive that there are direct benefits that accrue from the technology embodied in the imported inputs. It is not possible, however, to discern the exact channel that gives rise to this productivity boost. As is common in this literature, measuring total factor productivity is problematic because of the difficulty of separately identifying physical factor productivity from mark-ups. We control for mark-ups by including a Herfindahl index, and interact an industry concentration indicator with the tariff measures. The results show that gains from reducing input tariffs persist both for competitive and concentrated industries, but the benefits from reducing output tariffs exist only in the competitive industries.

Many studies have found that lower output tariffs have boosted productivity due to "import competition" effects. For example, Daniel Trefler (2004) shows that labor productivity increased by 14 percent in Canada and the United States in the industries that experienced the largest tariff cuts.[5] Nina Pavcnik (2002) shows that import competing industries in Chile enjoyed productivity gains up to 10 percent higher than gains in the nontraded goods sector due to liberalized trade.[6] Note that industries are classified as import-competing based on the total imports of those categories. However, firms within these categories may actually be importing their inputs rather than competing with imports. The import data at the plant level enable us to take account of this. Other studies on output tariffs and productivity include James Tybout, Jaime de Melo, and Vittorio Corbo (1991), James Levinsohn (1993), Ann E. Harrison (1994), Tybout and M. Daniel Westbrook (1995), Noel Gaston and Trefler (1997), Pravin Krishna and Devashish Mitra (1998), C. Keith Head and John Ries (1999), and Petia Topalova (2004).[7]

None of these studies takes account of input tariffs. They all draw on theoretical models that comprise only final goods, as in Paul R. Krugman (1979) and Elhanan Helpman and Krugman (1985), where productivity gains arise due to scale effects. In those models, exposure to foreign competition increases the elasticity of demand faced by domestic producers, reducing market power and forcing firms down their average cost curves. In contrast, Dani Rodrik (1988) shows that firms do not necessarily benefit from trade liberalization; for example, if there are barriers to exit, industries that contract will experience a fall in their average size.[8] Gains could also arise due to reallocation effects, with more efficient plants gaining market share and hence increasing average industry productivity (see Mark Roberts and Tybout 1991). Other potential gains can be grouped under the heading of externalities, which may be due to technical innovation (Gene M. Grossman and Helpman 1991), managerial effort (Max W. Corden 1974; Rodrik 1992), or domestic knowledge spillovers

[5] This is the only other study that uses highly disaggregated tariff data comparable to our study.

[6] This is the first study to carefully take account of the endogeneity of input choices in the first-stage estimation of total factor productivity (*TFP*) and to control for exit.

[7] The evidence from these firm-level studies is consistent with cross-country regression studies on output tariffs and growth (see John Romalis 2005).

[8] Bineswaree Bolaky and Caroline Freund (2004) show that trade does not stimulate growth in economies with excessive business and labor regulations.

and learning by doing (Krugman 1987; Robert Lucas, Jr., 1988, 1993; Alwyn Young 1991).

There are fewer theoretical models analyzing the effects of reducing input tariffs. In Corden (1971), lower input tariffs increase effective protection,[9] which reduces import competition, and thus could lead to lower productivity. In contrast, models by Wilfred Ethier (1982), James R. Markusen (1989), and Grossman and Helpman (1991) show that lower input tariffs can lead to increased productivity from access to more varieties of intermediate inputs, access to higher quality inputs, and through learning effects. Ours is the first study to provide empirical evidence that lower input tariffs directly benefit importing firms. A related study on Brazil by Adriana Schor (2004) shows that the effects of reducing input tariffs and output tariffs on productivity are of similar magnitude. This similarity could be due to the high level of aggregation (27 industries) of the tariffs, where some important variation is lost. Furthermore, unlike our study, Schor is unable to separately estimate the effect on importing firms. Using tariff data on nearly 300 industries, we show that importing firms enjoy the highest productivity gains from reducing input tariffs. Ana M. Fernandes (2003) indirectly accounts for the effect of input tariffs in a study on Colombia via a three-digit effective protection measure calculated by the national authorities, and thus she is unable to separately identify the effect from input tariffs.

Other studies that consider the effect of imported inputs on productivity are Robert C. Feenstra, Markusen, and William Zeile (1992), Marc-Andreas Muendler (2004), Lazlo Halpern, Miklos Koren, and Adam Szeidl (2005), and Kasahara and Rodrigue (2005), but none of these relates the effects to trade liberalization.[10] Feenstra, Markusen, and Zeile (1992) show that productivity, estimated at the industry level, is positively correlated with the introduction of new inputs in Korea. Muendler (2004) includes the foreign inputs in the first-stage productivity estimations for Brazil and finds this is a relatively unimportant channel of productivity. Kasahara and Rodrigue (2005) find that foreign inputs increase plant productivity in Chile by 2.3 percent, and Halpern, Koren, and Szeidl (2005) show that imports contributed 30 percent to growth in aggregate *TFP* in Hungary during the 1990s. Our study is also consistent with cross-country studies in the growth and trade literature, such as Xavier Sala-i-Martin, Gernot Doppelhofer, and Ronald I. Miller (2004), which shows that a low price of investment goods at the beginning of the period is positively related to subsequent income growth. Lowering input tariffs is a direct way of reducing the price of investment goods.[11]

The rest of the paper is organized as follows. Section I outlines the estimation strategy. Section II provides background on Indonesia's trade policy. Section III describes the data. Section IV presents the results. Section V concludes.

I. Model and Estimation Strategy

To determine the effect of trade liberalization on productivity, we consider a plant with a Cobb-Douglas production function,[12]

$$(1) \qquad Y_{it} = A_{it}(\tau) L_{it}^{\beta_l} K_{it}^{\beta_k} M_{it}^{\beta_m},$$

where output in firm i at time t, Y_{it}, is a function of labor, L_{it}, capital, K_{it}, and materials, M_{it}. We are interested in assessing whether the productivity of plant i is a function of trade policy, denoted by τ. In the first step we estimate plant-level *TFP*, and in the second step we specify how productivity can be affected by trade policy.

[9] Effective rate of protection is the percentage by which a country's trade barriers increase the value added per unit of output, taking into account that both input and output tariffs affect an industry's value added.

[10] Garrick Blalock and Francisco Veloso (forthcoming) focus on productivity benefits to domestic suppliers of inputs in Indonesia as a result of import competition. They do not examine the direct benefits to importing firms and do not consider the effects of trade liberalization. Beata S. Javorcik (2004) and Blalock and Paul Gertler (forthcoming) find evidence of vertical spillovers from domestic suppliers to foreign firms in Indonesia and Lithuania, respectively.

[11] Lower input tariffs can also be interpreted as lowering the price of international "outsourcing" of material inputs; thus, our results would suggest that international outsourcing is associated with higher *TFP*.

[12] We also report results where we use a translog production function.

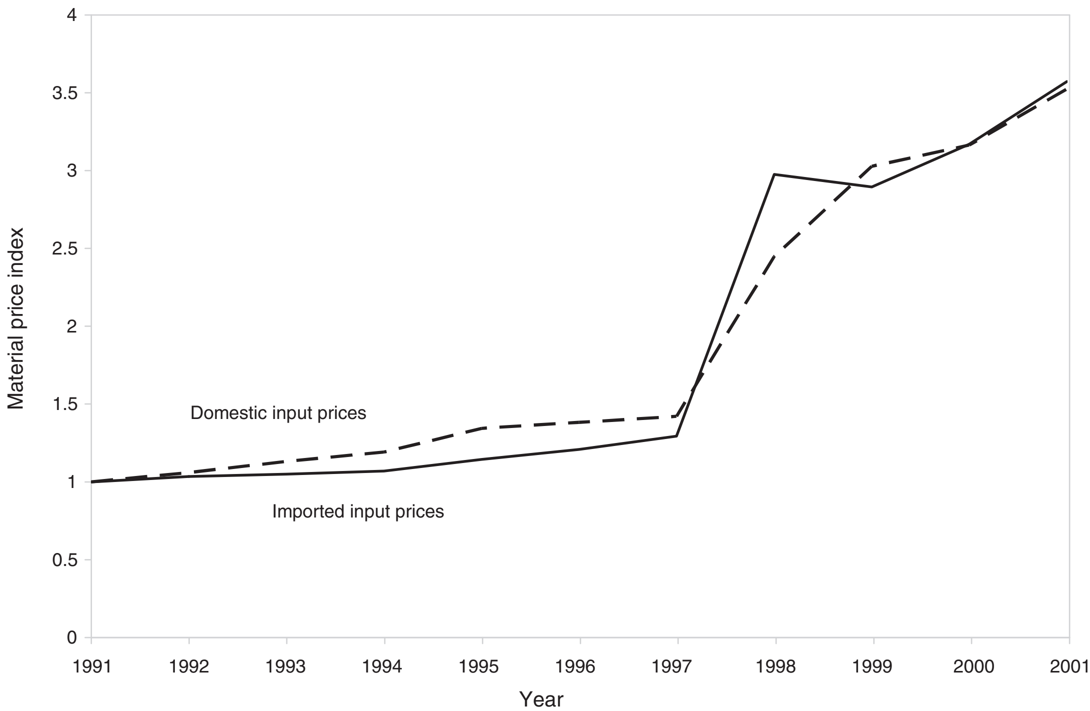

FIGURE 1. INPUT PRICE INDICES

A. *Productivity*

Taking the natural logs of equation (1), which we denote by small letters, we estimate

$$(2) \quad y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + e_{it}.$$

The dependent variable is total revenue at the plant level, deflated by five-digit industry-level producer price indices. Domestic and imported inputs are adjusted by separate deflators: domestically purchased material inputs are deflated with a five-digit price deflator, which we constructed by weighting the producer price deflators with the cost proportion of each input; imported material inputs are deflated with an official imported input price deflator.[13] A closer look at these material deflators shows that domestic and imported input prices generally move together (see Figure 1), though there is some deviation during the Asian crisis years where, as expected, imported input prices are on average higher. Indeed, one would expect that prices of imported inputs and domestic prices would move together, provided they were substitutes.

We use the Olley-Pakes methodology to estimate equation (2). This estimation procedure takes account of the simultaneity between input choices and productivity shocks, as well as sample selection bias (see Appendix for details). We modify the procedure to incorporate the firm's decision to enter the international market, via importing and/or exporting, and to take account of the Asian crisis. We assume that there is a fixed entry cost sunk into the import market analogous to the entry cost of entering the export market (see Marc Melitz 2003). This may be due to the search costs of finding the appropriate input or the adaptation costs to utilize the imported inputs. We estimate the

[13] The results are robust to deflating both domestic and imported material inputs by the same five-digit domestic materials deflators.

Table 2—Coefficients of the Production Function

Industry	Labor		Materials		Capital	
	OLS	OP	OLS	OP	OLS	OP
Food products (311)	0.304	0.273	0.747	0.708	0.058	0.067
Food products, nes[a] (312)	0.421	0.335	0.494	0.467	0.172	0.132
Beverages (313)	0.965	0.818	0.353	0.346	0.166	0.175
Tobacco (314)	0.159	0.105	0.875	0.875	0.036	0.000
Textiles (321)	0.249	0.212	0.728	0.708	0.058	0.064
Clothing (322)	0.277	0.253	0.743	0.724	0.039	0.070
Leather goods, nes[a] (323)	0.334	0.321	0.718	0.702	0.026	0.003
Leather footwear (324)	0.392	0.351	0.643	0.619	0.017	0.002
Wood and cork, except furniture (331)	0.296	0.276	0.698	0.677	0.046	0.061
Furniture (332)	0.303	0.285	0.690	0.677	0.052	0.046
Paper and paper products (341)	0.281	0.230	0.739	0.730	0.044	0.018
Printing, publishing, and allied industries (342)	0.419	0.292	0.645	0.657	0.053	0.063
Industrial chemicals (351)	0.312	0.173	0.561	0.497	0.150	0.178
Other chemical products (352)	0.409	0.376	0.641	0.607	0.094	0.121
Rubber products (355)	0.221	0.223	0.717	0.694	0.049	0.045
Plastic products, nes[a] (356)	0.247	0.203	0.745	0.717	0.049	0.056
Pottery, china, and earthware (361)	0.353	0.377	0.583	0.498	0.145	0.196
Glass and glass products (362)	0.381	0.278	0.668	0.640	0.059	0.120
Cement (363)	0.358	0.251	0.713	0.706	0.062	0.128
Clay products (364)	0.544	0.517	0.422	0.367	0.137	0.115
Other nonmetallic mineral products (369)	0.448	0.364	0.578	0.518	0.164	0.222
Iron and steel industries (371)	0.259	0.248	0.787	0.755	0.015	0.045
Nonferrous metal basic industries (372)	0.364	0.182	0.691	0.664	0.124	0.174
Fabricated metal products, except machinery (381)	0.315	0.285	0.714	0.701	0.040	0.031
Nonelectrical machinery (382)	0.327	0.268	0.693	0.677	0.080	0.044
Electrical machinery (383)	0.289	0.293	0.737	0.713	0.044	0.096
Transport equipment (384)	0.384	0.312	0.671	0.639	0.051	0.143
Professional, scientific, and equipment (385)	0.384	0.312	0.671	0.639	0.051	0.143
Miscellaneous manufacturing (390)	0.390	0.346	0.620	0.589	0.074	0.133

[a] "nes" refers to "not elsewhere classified."

production functions for plants in each three-digit sector separately.[14] Using the estimates of the production coefficients, we define the log of measured *TFP* of plant *i* at time *t* for each industry *k*, denoted by tfp_{it}^{k}, as

$$(3) \qquad tfp_{it}^{k} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it} \, .$$

The estimated input coefficients obtained from estimating equation (2) with Olley-Pakes are reported in Table 2. The OLS estimates are included for comparison. The labor and material coefficients are overestimated with OLS, as expected when labor and material usage is positively correlated with productivity shocks.

The *TFP* estimates from equation (3) are likely also to reflect firm-level differences in mark-ups. Without actual measures of physical quantities, it is impossible to measure physical *TFP* accurately. Deflating firm-level revenue with industry-wide price indices would be appropriate if all firms faced the same prices. However, with differentiated products and concentrated industries, this is unlikely to be the case. (See Jacob Klette and Zvi Griliches 1996; Levinsohn and Melitz 2002; and Haijime Katayama, Shihua Lu, and Tybout 2003 for a discussion of these issues.) Also, with multiproduct firms, measured productivity will be increasing in the number of products produced (see De Loeker 2006). Measured productivity can change as a result

[14] As the Olley-Pakes approach requires positive investment to estimate production function coefficients, it was not possible to estimate different production technologies at the more disaggregated level of four-digit or five-digit industry codes because the number of firm observations for some sectors was too small to allow for statistically sensible estimates. However, we will report OLS estimates with different production coefficients at the five-digit sector as a robustness check.

of changes in the choice of product mix over time, as shown in Andrew B. Bernard, Stephen Redding, and Peter K. Schott (2005). With plant fixed effects, our estimates control for the cross-sectional differences in productivity that may be caused by differences in the number of products that plants produce. If changes in *TFP* measures are reflecting changes in mark-ups, then this should be more pronounced in highly concentrated industries, where firms have more market power. We will use industry concentration indices to investigate this. Although we do not have measures of multiproduct firms, we have some indicators of firms that switched their main product, which we incorporate in our robustness checks, in Section IVB.

Further, it is not possible to separately identify differences in quality from differences in measured productivity. Whether any improvement in quality is reflected in measured productivity depends on how imported inputs are priced. If the quality of imported inputs is fully reflected in changes in input prices, then it will not show up in *TFP;* however, if the improvement in quality is greater than the change in the input price, then this could be reflected in a higher *TFP*. The use of separate deflators for domestic and imported inputs reduces the risk that differentials in *TFP* between importing and nonimporting firms are driven by differences in domestic and import prices.

B. *Trade Liberalization*

In the second stage, we specify the possible links between trade liberalization and plant-level productivity. Using the plant-level measures of *TFP* from equation (3), we estimate the equation

$$tfp_{it}^{k} = \gamma_0 + \alpha_i + \alpha_{lt} + \gamma_1 (output\ tariff)_t^k + \gamma_2 (input\ tariff)_t^k + \gamma_3 (input\ tariff)_t^k FM_{it} + \gamma_4 FM_{it} + \varepsilon_{it}\,, \quad (4)$$

using OLS with firm fixed effects, α_i, to control for unobserved firm-level heterogeneity. We also include interactive island-year fixed effects, α_{lt}, to control for shocks over time that affect productivity across all sectors but may vary across different islands within Indonesia.[15]

The output tariff in the first line of equation (4) is a simple average constructed at the five-digit ISIC industry k. We hypothesize that a fall in output tariffs will increase productivity $(\gamma_1 < 0)$, as the increase in import competition is likely to force firms to search for ways to improve their efficiency.

In the second line of equation (4), we include an input tariff for each industry k as a weighted average of all output tariffs, where the weights are based on the cost shares of each input used. Reducing input tariffs could offset some of the import competition effects that arise from lower output tariffs, as many firms are affected by both output and input tariffs. This was the idea behind the effective protection literature (see Corden 1971). For example, a lower input tariff, by reducing material input costs, could reduce the incentives for firms to pursue more efficient production techniques.

More recent literature emphasizes the benefits that accrue from lower input tariffs, by making foreign inputs more accessible. A higher usage of foreign inputs can increase firm productivity due to learning effects from the foreign technology embodied in the imported inputs, from higher-quality inputs, and from more input varieties. Although we are unable to separately identify which of these channels actually boosts productivity, we hypothesize that if the gains are due to the foreign technology embodied in the inputs, the importing firms should reap the largest benefits from these direct effects. Thus, we interact input tariffs with a firm-level indicator of importing firms, denoted by *FM*, which equals one if the firm imports any of its intermediate inputs; in some specifications, it is interacted with the actual share of imported inputs to total inputs. A negative and significant coefficient on the interaction term, γ_3, would imply that importing firms do reap higher benefits from lower input tariffs than nonimporting firms. We hypothesize that γ_4 is positive, indicating that imported inputs generate some kind of technological externality.

[15] There are five island dummies: Sumatra, Java, Kalimantan, Sulawesi, and the outer islands.

A negative and significant γ_2 would suggest that there are also indirect positive effects spreading from importing to nonimporting firms. As importing firms become more productive, they can pass on benefits to other firms through sales of their goods along the vertical production chain, for example. A fall in the price of imported inputs can force domestic producers of substitutes to become more competitive by becoming more innovative, passing on benefits to users of domestic inputs. Alternatively, they could lower domestic prices by trimming fat. We expect these indirect effects to be of lower magnitude than the direct effects.

II. Trade Policy in Indonesia

Indonesia became a WTO member on January 1, 1995, at which time it gave a commitment to reduce all bound tariffs to 40 percent or less over a ten-year period, starting in 1995, subject to an exclusion list of products for which this commitment did not apply.[16] There were 73 five-digit ISIC codes that included at least one excluded Harmonized System (HS) code, and only nine ISIC codes which contained ten or more excluded HS codes. The industries with the highest number of exclusions were motor vehicles and components, and iron and steel basic industries. Plotting the change in tariffs over the sample period, 1991 to 2001, as a function of tariffs at the beginning of the sample, we see from Figure 2 that the industries with the highest initial tariffs experienced the largest tariff reductions. Note there were four product groups in the sample (not included in the figure) for which tariffs actually increased over the period. These were liquors and wine (ISIC codes 31310 and 31320) and rice milling (ISIC codes 31161 and 31169).

In order to identify the effects of tariff reductions on productivity, an important question is whether the trade reform process is endogenous, as this would lead to biased estimates. There is a large political economy literature that argues that certain industries have more political power to lobby governments for protection (see Grossman and Helpman 1994). For Indonesia, however, Mobarak and Purbasari (2005) find that political connections do not affect tariff rates. They regress tariffs at the industry level on a political connection indicator and find this is insignificant. They explain their result by arguing that it is difficult for governments in developing countries to provide favors in the form of high-output tariffs because they are under the close scrutiny of international organizations, such as the International Monetary Fund (IMF). Instead, political favors are given at the firm level in a less transparent way. The authors show that politically connected firms in Indonesia receive benefits by way of the right to import.[17] Their study implies that the endogeneity of tariffs may not be so serious in the case of Indonesia.

The potential bias due to endogeneity is also reduced because our estimates all include fixed effects, so if political economy factors are time invariant, this is already accounted for (see Pinelopi K. Goldberg and Pavcnik 2005). But, time-varying industry characteristics could simultaneously influence productivity and tariffs. To address this, Trefler (2004) proposes using the share of unskilled labor in total employment as an instrument to reflect an industry's propensity to get organized. As a robustness check, we estimate equation (4) using two-stage least squares with a number of different instruments. Following Trefler (2004), we use the share of unskilled labor in total employment, and following Goldberg and Pavcnik (2005), we use the 1991 levels of tariffs as instruments for changes in tariffs.

Another important form of protection provided to industries is through nontariff barriers (NTBs), which are generally very difficult to measure. We experimented with an NTB measure equal to one post-1995 for five-digit product codes, where at least one HS nine-digit product was listed as having an NTB that the

[16] The tariff lines are at the HS nine-digit level, comprising thousands of product codes. For the exclusion list, see http://www.wto.org/english/tratop_e/schedules_e/goods_schedules_e.html.

[17] Note that these license requirements have no impact on our study. Less than 1 percent of firms were issued with an import license, and these licenses were required only for importing raw material inputs. The licensing did not apply to imported manufactured material inputs, which is the focus of our study. In most product groups, any firm is allowed to import inputs. As a robustness check, we reestimate the equations excluding firms with import licenses. We are grateful to Mobarak for providing us with these data.

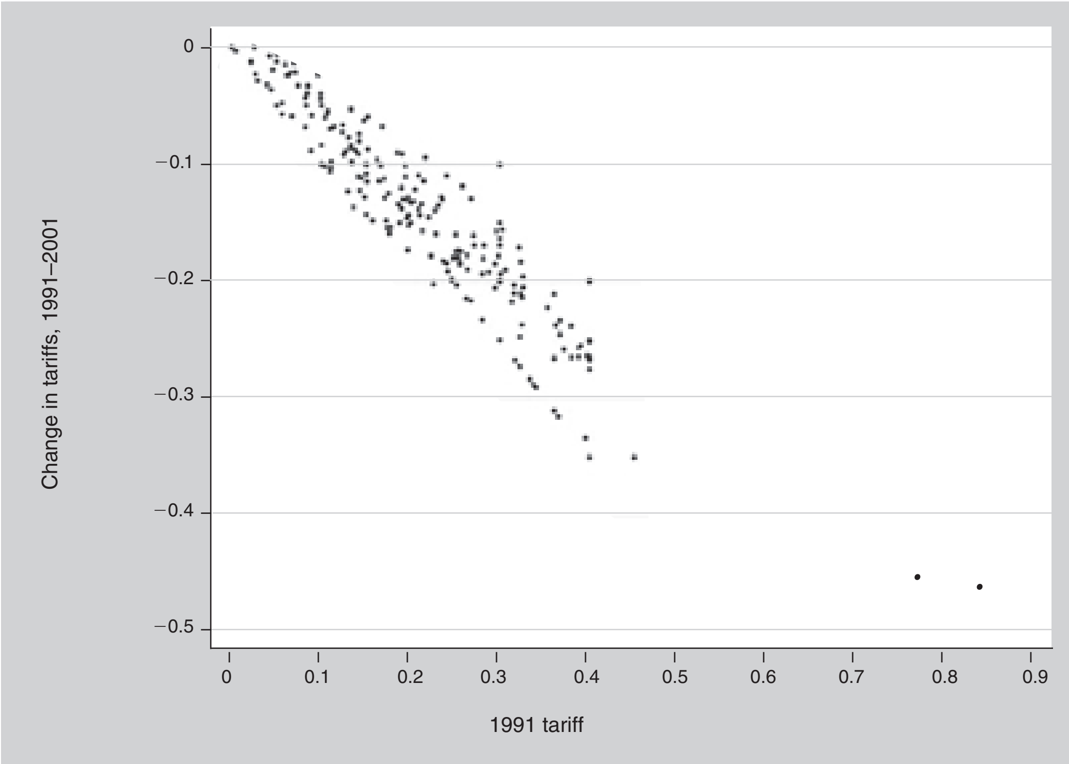

Figure 2. Change in Tariffs, 1991–2001, Relative to Initial Levels

Note: Industries that experienced an increase in their tariff over the sample period are excluded from the figure. These are industries 31161, 31169, 31310, and 31320.

Indonesian government agreed to remove over a ten-year period beginning 1995. There were 17 such five-digit product codes. We found that this NTB measure had an insignificant effect on productivity. Most of the NTBs to be removed (43 HS codes) fell within the ISIC industry code 37101 (iron and steel basic industries). We also experimented with an NTB post-1995 indicator for this industry code only. Again, we found that this had an insignificant effect on productivity. These insignificant coefficients could be due to two reasons: the NTBs are measured imprecisely, or the Indonesian government had not yet removed the NTBs during our sample period, since it had until 2004 to meet those obligations. Unfortunately, we were unable to find any further information on NTBs; thus the rest of the analysis focuses on the effects of tariff reform.

III. Data

Our main data source is the Manufacturing Survey of Large and Medium-Sized Firms (Survei Industri, SI) for 1991 to 2001. This is an annual census of all manufacturing firms in Indonesia with 20 or more employees. The SI data capture the formal manufacturing sector with plant-level data on output, intermediate inputs, labor, capital, imports, exports, and foreign ownership. We use data on outputs and inputs, deflated by wholesale price indices, to obtain productivity estimates.[18] We construct

[18] Industry wholesale price indices (WPI) are used to deflate plant-level sales revenue. These are published in the Buletin Statistik Bulanan Indikator Ekonomi of the Indonesian Statistical Agency (Badan Pusat Statistic, BPS), the Monthly Statistical Bulletin of Economic Indicators.

domestic input deflators by weighting the final goods wholesale prices with their cost shares as intermediate inputs and use officially published import price deflators for the imported inputs.

The input data provided in this dataset are unusually rich. The SI questionnaire asks each firm to list all of its individual intermediate inputs and the amount spent on each in rupiah. Although this information is not routinely prepared, it was coded by the BPS and made available to us for the year 1998. For all other years, we have total expenditure on domestic inputs and imported inputs, but not by individual type of input.[19] We aggregate the 1998 data within five-digit industry categories to create a 288 manufacturing input/output table.[20] We assume that the mix of inputs used by industries does not change over our sample period, essentially assuming a Cobb-Douglas technology. The input data are of particular importance for this study as they enable us to construct an input tariff for each five-digit industry.

The input tariffs are calculated as follows. First, we construct a five-digit output tariff by taking a simple average of the HS nine-digit codes within each five-digit industry code. The HS nine-digit tariffs are from the Indonesia Industry and Trade Department. We were able to match the international and production data with the help of an unpublished concordance between the HS nine-digit classification and the five-digit ISIC from BPS.[21] Second, for each five-digit industry, we compute an input tariff as a weighted average of the output tariffs,

$$(5) \quad \textit{input tariff}_t^k = \sum_j w_{jk}^{1998} \times \textit{output tariff}_t^j,$$

$$\text{where } w_{jk}^{1998} = \frac{\sum_i input_{ijk}^{1998}}{\sum_{ij} input_{ijk}^{1998}}.$$

The weights, w_{jk}^{1998}, are the cost shares of industry j in the production of a good in industry k, based on firm-level data in 1998, aggregated up to the industry level. Thus, if industry k uses 70 percent steel and 30 percent rubber, we give a 70 percent weight to the steel tariff and a 30 percent weight to the rubber tariff. It is important to note that these input tariffs are constructed at the industry level and not at the firm level.[22] Further, the cost shares are based on total input purchases, including domestic and imported inputs. If the weights included only imported inputs, this would introduce an endogeneity bias. Our approach aims to assign the most relevant input tariff to each industry. Thus, if an industry is intensive in rubber usage, the relevant tariff is the tariff on rubber irrespective of whether the rubber is imported. There may be concern that the weights are based on a year during the Asian crisis. To address this, we also construct input tariffs using cost shares from the 1995 input/output table, but these are at a more aggregate level.

There is variation in average tariffs between industries and over time (see Table 1). In general, input tariffs are lower than output tariffs, and both have been on a downward trend over the sample period, although the largest reductions

We used an unpublished concordance from the BPS to map the 192 WPI industry codes into the five-digit ISIC product codes. The capital price deflator is a weighted average of the aggregate price index of imported electrical and non-electrical machinery and equipment, imported transport goods, and the wholesale price index of manufactured construction materials. The weights are based on information in the SI on the use of each of these components at the four-digit ISIC level. (These could not be constructed at the five-digit level because some of the components were missing for some five-digit industries.)

[19] These imported inputs include inputs that are directly imported by the firm, as well as imported inputs purchased from local distributors.

[20] Note that there are actually 307 five-digit ISIC industry codes but only 288 are in our sample.

[21] This concordance was incomplete, so a large portion of the product codes were manually matched by the authors based on product descriptions. Some of the five-digit industries had to be grouped together; for example, it was difficult to separate rice milling from other grain milling products, so these two industries were grouped together. This resulted in a total of 225 output tariff codes; however, there are a larger number of input tariffs (288) since different industries use inputs in different proportions.

[22] It would be possible to construct a firm-level input tariff only for those firms that exist in 1998, but this would cause problems relating to sample selection bias and would introduce an endogeneity problem. For example, if importers are able to access cheaper inputs, their weighted tariff might appear lower than that of firms that purchase domestic inputs, providing a positive correlation between importers and productivity. To avoid this potential pitfall, all tariffs are constructed at the industry level.

took place after 1994. The correlation between output tariffs and input tariffs is 0.66.[23]

We begin our analysis in 1991 to avoid the reclassification of industry codes between 1990 and 1991, and because the capital stock data from earlier years were less complete. The data needed to be cleaned due to missing variables for some observations and large unrealistic numbers.[24] The final dataset is an unbalanced panel of around 15,000 firms per year with a total of 170,741 observations. Summary statistics are provided in Table 3.

IV. Results

We estimate equation (4) as an unbalanced panel with plant fixed effects for the period 1991 to 2001. All equations include island-year fixed effects. The errors have been corrected for heteroskedasticity at the plant level.[25]

A. *Productivity and Tariffs*

The results from estimating equation (4) are presented in Table 4. First, we regress *TFP* only on final goods tariffs, as is common in the literature, as a benchmark. Column 1 of Table 4 shows that a fall in output tariffs of 10 percentage points increases productivity by 2.1 percent. This significant negative coefficient is consistent with the literature. See, for example, Pavcnik (2002), where the effect is 2.8 percent in a similar specification. Once we include input tariffs, in column 2, the coefficient on output tariffs is more than halved. The point estimate suggests that a 10 percentage point fall in tariffs increases productivity by only 0.7 percent. In contrast, the coefficient on input tariffs is much higher, indicating that a 10 percentage point fall in input tariffs increases productivity by 4 percent. The results show that the productivity gains from reducing input tariffs are much higher than those from reducing output tariffs. Further, comparison of columns 1 and 2 suggests there is an omitted variable bias in column 1.

If productivity gains from reducing input tariffs are due to the technology embodied in foreign inputs, we would expect that importing firms would enjoy the largest gain from this direct effect. To check this, we interact input tariffs with an indicator of importing status, *FM*. Firms are classified as importing if they import any of their inputs.[26] In column 3, we see that the coefficient on this interactive term is negative and significant, equal to −0.91. This shows that firms that import their inputs do indeed enjoy a larger productivity gain than nonimporting firms, which is what we would expect if there are benefits arising from higher-quality inputs, more varieties of inputs, or learning effects. Adding this coefficient to the overall input tariff effect indicates that a fall in input tariffs of 10 percentage points improves productivity for importing firms by 12 percent, whereas nonimporting firms benefit by only 3 percent. The coefficient on importing firms, *FM*, is positive and significant as expected, showing that importing firms are 9.2 percent more productive on average than nonimporting firms.

In column 4, we control for the exit of firms by including a dummy variable equal to one if the firm exits in the following period. The results indicate that firms that exit are on average 4 percent less productive than those that remain in the market. The inclusion of the exit indicator hardly affects any of the other coefficients. In column 5, we include firm-level characteristics. In general exporters and foreign owned firms are expected to have higher productivity than domestic firms. The exporter dummy, *FX*, is equal to one for firms that export any of their output, and the foreign dummy, *FF*, is equal to one if foreign ownership is greater than or equal to 10 percent. The coefficient on the foreign firm indicator is positive and significant, yet the export dummy is negative. However, once we include the actual share of exports, in column 6, rather than a dummy indicator, the coefficient is insignificant.

[23] Note that this is the correlation after the tariff data have been merged with the firm data. The correlation at the industry level is much lower, at 0.47.

[24] The capital stock, measured by the replacement value of fixed assets, was missing for the year 1996; thus, we interpolated it based on values from 1995 and 1997. We excluded plants with unrealistically large spikes in the data, by dropping the first and ninety-ninth percentiles of the distribution of plant-level output growth and input growth.

[25] The footnotes of the tables also provide information on clustering at the industry-year level. Our main conclusions are unaffected by the clustering groupings.

[26] The results are robust to defining importers with a share of imported inputs greater than 10 percent.

Table 3—Summary Statistics

Variable	Observations	Mean	Standard deviation
Output tariff	170,741	0.159	0.113
Output tariff$_t$ − Output tariff$_{t-2}$	111,107	−0.037	0.057
Output tariff$_t$ − Output tariff$_{t-5}$	56,320	−0.106	0.092
Output tariff$_t$ − Output tariff$_{t-9}$	6,089	−0.163	0.116
Output tariff–3 digit	170,741	0.166	0.138
Output tariff on the basis of the IO table	170,741	0.110	0.207
Output weighted tariff	170,741	0.163	0.297
Input tariff	170,741	0.101	0.062
Input tariff$_t$ − input tariff$_{t-2}$	111,107	−0.018	0.031
Input tariff$_t$ − input tariff$_{t-5}$	56,320	−0.053	0.050
Input tariff$_t$ − input tariff$_{t-9}$	6,089	−0.082	0.064
Input tariff–3 digit	170,741	0.129	0.061
Input tariff on the basis of the IO table–1995	170,741	0.078	0.095
Input tariff on the basis of the IO table–1998	170,741	0.068	0.078
Input weighted tariff	170,741	0.099	0.227
Log real output	170,468	8.160	2.106
ln(TFP)–Olley-Pakes	170,741	1.639	0.671
ln(TFP$_t$)–ln(TFP$_{t-5}$)–Olley-Pakes	56,320	0.124	0.527
ln(TFP)–OLS	170,741	1.331	0.597
ln(TFP)–no foreign	170,741	1.653	0.665
ln(Value added per worker)	165,025	3.199	1.293
ln(L)	170,740	4.247	1.230
ln(K)	169,527	7.069	2.275
ln(K/L)	170,740	2.816	1.721
ln(Materials)	170,570	7.222	2.307
ln(Total inputs)	170,570	12.969	2.377
Import share	170,741	0.098	0.250
FM = 1 if import share ≥ 0	170,741	0.207	0.405
FM$_t$ − FM$_{t-2}$	111,107	−0.009	0.263
FM$_t$ − FM$_{t-5}$	56,320	−0.019	0.341
FM$_t$ − FM$_{t-9}$	6,089	−0.049	0.408
High FM[a]	170,741	0.102	0.303
Export share	170,741	0.118	0.297
FX = 1 if export share > 0	170,741	0.167	0.373
FX$_t$ − FX$_{t-2}$	111,107	−0.010	0.354
FX$_t$ − FX$_{t-5}$	56,320	−0.046	0.393
FX$_t$ − FX$_{t-9}$	6,089	0.002	0.394
Foreign share	170,741	0.048	0.190
FF = 1 if foreign share ≥ 0.1	170,741	0.065	0.247
FF$_t$ − FF$_{t-2}$	111,107	0.001	0.125
FF$_t$ − FF$_{t-5}$	56,320	0.002	0.153
FF$_t$ − FF$_{t-9}$	6,089	0.005	0.167
ln(TWI)	170,741	−0.737	0.601
ln(TWI$_t$) − ln(TWI$_{t-5}$)	56,320	−0.999	0.384
Switch = 1 if firm switches products	170,741	0.148	0.355
Crisis dummy = 1 if year = 1997 or 1998	170,741	0.198	0.399
Herfindahl index–4-digit level	170,741	0.069	0.091
Herf$_t$ − Herf$_{t-2}$	111,107	−0.002	0.067
Herf$_t$ − Herf$_{t-5}$	56,320	0.002	0.082
Herf$_t$ − Herf$_{t-9}$	6,089	−0.016	0.117
Highly concentrated industry (Herfindahl > 0.25)	170,741	0.053	0.223
Exit = 1 if firm exits next year	170,741	0.063	0.243

[a] High FM indicates importing firms in industries with more than 40 percent of firms.

TABLE 4—BASIC RESULTS

Dependent variable: $\ln(\mathrm{TFP}_{it})$	(1)	(2)	(3)	(4)	(5)	(6)
Output tariff_t^k	−0.206***	−0.070*	−0.092**	−0.096**	−0.096**	−0.095**
	(0.033)	(0.042)	(0.043)	(0.043)	(0.043)	(0.043)
Input tariff_t^k		−0.441***	−0.318***	−0.315***	−0.315***	−0.325***
		(0.062)	(0.063)	(0.063)	(0.063)	(0.063)
Input $\mathrm{tariff}_t^k \times \mathrm{FM}_{it}$			−0.914***	−0.899***	−0.896***	
			(0.086)	(0.086)	(0.086)	
$\mathrm{FM}_{it} = 1$ if import share > 0			0.092***	0.091***	0.089***	
			(0.012)	(0.012)	(0.012)	
Input $\mathrm{tariff}_t^k \times$ import share_{it}						−1.908***
						(0.164)
Import share_{it}						0.233***
						(0.024)
$\mathrm{FX}_{it} = 1$ if export share > 0					−0.010**	
					(0.005)	
Export share_{it}						−0.008
						(0.006)
$\mathrm{FF}_{it} = 1$ if foreign share ≥ 0.1					0.070***	
					(0.017)	
Foreign share_{it}						0.079***
						(0.023)
$\mathrm{Exit}_{it} = 1$ if firm exits in $t + 1$				−0.040***	−0.040***	−0.040***
				(0.004)	(0.004)	(0.004)
Island × year effects	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes
Observations	170,741	170,741	170,741	170,741	170,741	170,741
R-squared	0.80	0.80	0.80	0.80	0.80	0.80

Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If, instead, error terms were corrected for clustering at the industry-year level, all significant variables remain significant with p-values < 0.05, except *output tariff* in columns 2 through 6 becomes insignificant.

*** Significant at, or below, 1 percent.
** Significant at, or below, 5 percent.
* Significant at, or below, 10 percent.

Since all of the estimations include firm fixed effects, the additional firm characteristic indicators only pick-up changes over time.[27]

We show that the results also hold when the share of imported inputs (rather than an importing firm dummy) is interacted with input tariffs, and we include actual export shares and foreign ownership shares. The results from this specification, in column 6, are almost identical to those in column 5. The coefficient on the interaction term between input tariffs and import share is equal to −1.9. Multiplying this by the mean import share for importing firms (equal to 0.47) gives an effect equal to 0.9, almost the same as the effect on input tariffs interacted with an importing firm dummy in columns 3 to 5.

[27] Regressing *TFP* on firm characteristics without firm fixed effects shows that exporters are on average more productive than other firms. These findings are consistent with Bernard and J. Bradford Jensen (1999), which shows that high productivity firms self-select into exporting.

Table 5—Alternative Productivity Measures

Dependent variable:	ln(real value added per worker$_{it}$)			ln(real output$_{it}$) Cobb-Douglas technology		ln(TFP$_{it}$) Cobb-Douglas technology		ln(TFP$_{it}$) Translog technology	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Output tariff$_t^k$	−0.553***	−0.533***	−0.267***	−0.212***	−0.158***	−0.162***	−0.058	−0.236***	−0.167***
	(0.065)	(0.065)	(0.073)	(0.032)	(0.043)	(0.030)	(0.040)	(0.031)	(0.040)
Input tariff$_t^k$			−0.793***		−0.168***		−0.302***		−0.186***
			(0.124)		(0.063)		(0.058)		(0.059)
Input tariff$_t^k$ × FM$_{it}$			−1.186***		−0.775***		−0.743***		−0.787***
			(0.160)		(0.088)		(0.082)		(0.081)
FM$_{it}$ = 1 if import share > 0			0.233***		0.090***		0.066***		0.090***
			(0.022)		(0.012)		(0.011)		(0.011)
FX$_{it}$ = 1 if export share > 0			0.007		−0.003		−0.007		0.003
			(0.009)		(0.005)		(0.005)		(0.005)
FF$_{it}$ = 1 if foreign share ≥ 0.1			0.179***		0.072***		0.053***		0.081***
			(0.030)		(0.017)		(0.017)		(0.016)
Exit$_{it}$ = 1 if firm exits in t + 1			−0.083***		−0.032***		−0.031***		−0.034***
			(0.009)		(0.005)		(0.004)		(0.004)
ln(K/L)$_{it}$		0.058***	0.060***						
		(0.003)	(0.003)						
ln(real inputs$_{it}$) × prod5d [a]				yes	yes				
Island × year effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	165,025	165,025	165,025	170,741	170,741	170,741	170,741	169,217	169,217
R-squared	0.81	0.81	0.81	0.74	0.75	0.80	0.80	0.98	0.98

Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If, instead, error terms were corrected for clustering at the industry-year level, all significant variables remain significant with p-values < 0.05, except *output tariff* in column 5 becomes insignificant, *FX* in column 9 becomes insignificant, and *input tariff* in column 9 becomes insignificant, but the interactive *input tariff* × *FM* remains significant in all columns.

[a] The inputs, labor, real capital, and real materials, are all interacted with five-digit industry dummies.

*** Significant at, or below, 1 percent.

** Significant at, or below, 5 percent.

* Significant at, or below, 10 percent.

Alternative Productivity Measures.—The results are robust across different measures of productivity. In addition to the Olley-Pakes estimates of *TFP*, we use OLS estimates with different functional forms for the production function. In the first three columns of Table 5, productivity is measured as value added per worker, defined as the difference between real output and real intermediate inputs divided by total employment. In columns 1 and 2, we compare the results from regressing log real value added per worker on final goods tariffs, with and without capital per worker, respectively. We see that reducing output tariffs also increases labor productivity. The effect is much higher than it was for *TFP,* and the results are not sensitive to the inclusion of capital per worker; the estimated coefficients on output tariffs in columns 1 and 2 are almost identical. In column 3, we add input tariffs and interact this with importing firms. The pattern is consistent with the *TFP* results in Table 4. That is, by including input tariffs, the coefficient on output tariffs is once again more than halved (from −0.53 to −0.27) and the coefficient on input tariffs is much higher. Moreover, the coefficient on the interactive input tariffs with importing firms is large and significant, indicating that importing firms also enjoy higher labor productivity.

In columns 4 and 5, we estimate the effect of tariff reform on *TFP* in one stage using OLS, assuming Cobb-Douglas production functions. The dependent variable is real output. The inputs (labor, capital, and materials) are interacted with five-digit industry dummies. This produces similar results to those in Table 4, where *TFP* is estimated using Olley-Pakes in the first stage for three-digit industries and the effect of reducing tariffs on *TFP* is estimated in the second stage. As a comparison, we estimate the effect of trade liberalization on *TFP* in two stages with OLS in columns 6 and 7. Again, the magnitudes of the coefficients are very close to those in Table 4. In columns 8 and 9, we follow the same procedure but now allow for a more flexible production technology using a translog function. The same general pattern also persists with this more flexible production technology.

B. *Channels of Productivity Growth*

For all of these productivity measures, real output is calculated as firm-level output deflated by industry-level price indices, so the productivity estimates are unlikely to accurately capture differences in efficiency. It is difficult to ascertain whether the increase in measured productivity is reflecting real efficiency gains arising from factors such as learning, variety, and foreign technology embodied in inputs, or is picking up changes in mark-ups. To check for this, we add a Herfindahl concentration index, defined as the sum of the squared market shares in each four-digit sector. It is hypothesized that firms are likely to have the ability to charge higher mark-ups in more concentrated industries. In column 1 of Table 6, we see that the coefficient on the Herfindahl index is negative and significant, suggesting that firms in highly concentrated industries have lower average productivity, and its inclusion does not affect any of the other coefficients.[28] To ensure that the coefficients on the tariff variables are not just picking up higher mark-ups, we interact the tariff terms with a dummy indicator for highly concentrated industries (with a Herfindahl index in the seventy-fifth percentile, equal to 0.25). The results in column 2 show that the output tariff interacted with a high concentration dummy is indeed positive and significant, suggesting that gains from reducing output tariffs accrue only to firms in competitive industries. Conversely, firms in highly concentrated industries experience a fall in productivity following a decrease in output tariffs. This could be interpreted as import competition squeezing mark-ups, or that trade liberalization leads to a fall in physical productivity in highly concentrated industries.[29] In contrast, the concentration dummy interacted with *input tariff* $\times$ *FM* is insignificant, indicating that productivity gains for importing firms are present in both high- and low-concentration industries.[30]

Measured productivity may also deviate from physical productivity when firms produce multiple products and/or switch their product mix. Further, trade liberalization may lead firms to switch their product mix from low- to high-productivity products. Our dataset does not include information on multi-product firms, but we know whether a firm switches the main product it produces. The switching dummy is set equal to one from the first year that a firm reports a different five-digit industry code from its original product code. In column 3, where we simply add this switching dummy, its coefficient is positive and significant, indicating that firms that switch their industry category are on average 2.9 percent more productive than other firms. In column 4, we interact the switching dummy with the tariff terms. Note that the interactive switching term on output tariffs is negative and significant, showing that some of the gains from reducing output tariffs arise from firms switching into high-productivity products, consistent with Bernard, Jensen, and Schott (2006). Yet the switching dummy interacted with *input tariff* $\times$ *FM* is insignificant, suggesting that the productivity gains to importers from reducing input tariffs are not due to product switching.

[28] A five-digit Herfindahl index produces an insignificant coefficient. Within some five-digit industries, there are very few firms; thus, the entry or exit of a small number of firms can induce large movements in the index. Incorporating imports into the Herfindahl index to take account of foreign competition also produced insignificant coefficients at the four-digit and five-digit level.

[29] See Rodrik (1988) and Tybout (2003).

[30] Defining a lower cut-off, say equal to the median of 0.11, results in insignificant interactive terms on both output and input tariffs.

TABLE 6—CHANNELS

Dependent variable: $\ln(TFP_{it})$	Mark-ups		Product switchers		No foreign firms	Exporters	No licensed firms
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Output tariff$_t^k$	−0.094**	−0.138***	−0.097**	−0.090***	−0.048	−0.095**	−0.088**
	(0.043)	(0.039)	(0.043)	(0.028)	(0.043)	(0.043)	(0.043)
Output tariff$_t^k$ × high concentration$_t^k$		0.231***					
		(0.049)					
Output tariff$_t^k$ × switch$_{it}$				−0.069*			
				(0.039)			
Input tariff$_t^k$	−0.318***	−0.286***	−0.310***	−0.315***	−0.359***	−0.318***	−0.318***
	(0.063)	(0.061)	(0.063)	(0.042)	(0.063)	(0.063)	(0.063)
Input tariff$_t^k$ × FM$_{it}$	−0.896***	−0.908***	−0.887***	−0.882***	−0.655***	−0.876***	−0.892***
	(0.086)	(0.086)	(0.086)	(0.064)	(0.089)	(0.090)	(0.087)
Input tariff$_t^k$ × FM$_{it}$ × high concentration$_t^k$		0.068					
		(0.134)					
Input tariff$_t^k$ × FM$_{it}$ × switch$_{it}$				−0.003			
				(0.085)			
Input tariff$_t^k$ × FM$_{it}$ × FX$_{it}$						−0.048	
						(0.072)	
FM$_{it}$ = 1 if import share > 0	0.090***	0.090***	0.089***	0.088***	0.058***	0.090***	0.092***
	(0.012)	(0.012)	(0.012)	(0.009)	(0.012)	(0.012)	(0.012)
FX$_{it}$ = 1 if export share > 0	−0.010**	−0.010**	−0.010**	−0.010**	−0.007	−0.007	−0.007
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
FF$_{it}$ = 1 if foreign share > 0.1	0.070***	0.070***	0.070***	0.070***			
	(0.017)	(0.017)	(0.017)	(0.014)			
Exit$_{it}$ = 1 if firm exits in $t + 1$	−0.040***	−0.040***	−0.040***	−0.040***	−0.047***	−0.040***	−0.040***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Herfindahl index$_t^k$	−0.080***	−0.185***	−0.081***	−0.080***	−0.073***	−0.080***	−0.081***
	(0.021)	(0.030)	(0.021)	(0.019)	(0.021)	(0.021)	(0.020)
Switch$_{it}$			0.029***	0.038***			
			(0.006)	(0.008)			
Island × year effects	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes
Observations	170,741	170,741	170,741	170,741	159,640	170,741	167,953
R-squared	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If, instead, error terms were corrected for clustering at the industry-year level, all significant variables remain significant with p-values < 0.05, except *output tariff* in columns 1, 3, 6, and 7 becomes insignificant, *output tariff* in column 2 is significant only at the 10 percent level, *Herfindahl index* in columns 1, 5, and 6 becomes insignificant, and *Herfindahl index* in columns 3 and 7 is significant only at the 10 percent level.

*** Significant at, or below, 1 percent.
** Significant at, or below, 5 percent.
* Significant at, or below, 10 percent.

Another possible link between productivity gains and input tariff reductions may be due to changes in foreign ownership over the period, particularly if firms with high import shares are being purchased by foreign firms. To rule out this possibility, we reestimate the basic equation excluding foreign firms from the sample. We also exclude foreign firms from the estimation of *TFP* using the Olley-Pakes methodology to ensure that the production coefficients in estimating *TFP* are not biased due to heterogeneity between domestic and foreign firms' production technologies.[31] From column 5, we see that excluding foreign firms from the sample does not affect the main conclusions: domestically owned importers enjoy a 10 percent productivity gain from a 10 percentage point fall in input tariffs.

It is possible that importers enjoy these productivity improvements because they are exporting their final products. To check for this channel of productivity growth, we interact an export dummy with *input tariff* × *FM* in column 6. We find that this interactive term is insignificant, suggesting there is no additional gain from input tariff reductions to those firms that are both importers and exporters. In column 7, we omit any firm that has been granted an import license to ensure that there is no spurious correlation between those firms with an import license and measured productivity.[32] The results are identical to those with the full sample.

C. *Alternative Tariff Measures*

In order to identify the separate effects of reducing output and input tariffs on productivity, it is essential to have tariffs at a high level of disaggregation. We demonstrate this by reestimating the equations with tariffs aggregated to the three-digit ISIC level (29 industries). Within three-digit categories, the main inputs often come from within the same category as the output, thus leading to high levels of correlation between the input and output tariffs. As is typical with cases of multicollinearity, we see low t-statistics on the coefficients on tariffs in columns 1 and 2 of Table 7.[33] Another consequence of mulitcolinearity is that the size and signs of coefficients bounce around with small changes in the sample. This can be seen in columns 3 and 4, where we reestimate the equations using the three-digit tariffs but exclude the liquor industry. The coefficients are much larger and the coefficient on the input tariff changes its sign from negative in column 2 to positive in column 4. In contrast, dropping the liquor industry from the sample with the five-digit tariffs leaves the results unchanged, in column 5, compared to a similar specification with the full sample in column 2 of Table 4.

Thus far, we have used simple averages to aggregate tariffs from the HS nine-digit to ISIC five-digit level. Alternatively, one could weight the HS nine-digit tariffs by the share of imports. The main disadvantage of using import weights is that very high tariffs often receive low weights due to low import values within those categories. Further, if weights were to change each year it would introduce an endogeneity problem. To avoid this, it is common to fix the weights either at the beginning or the end of the period or to take an average of the base and current year to construct an ideal Fisher index. But, another potential problem arises with fixed weights where an average tariff appears as zero each year, even though there might be a positive tariff and positive trade in that year. We avoid these problems by using simple averages in our main estimations. As a robustness check, we present estimates of the effect of trade liberalization on productivity using import-weighted tariffs, with 1991 weights, in columns 6 and 7 of Table 7.[34] These results are similar to those with simple average tariffs, except that the output tariff in column 7 is insignificant.

[31] The results are the same if we exclude firms with any share of foreign ownership. Only 6.5 percent of the firms in the sample have any foreign ownership. Susan E. Feinberg and Michael P. Keane (2001, 2005) provide evidence that multinational firms operate differently from domestic firms, having access to different technologies, which could imply different factor shares.

[32] There are 340 firms that had import licenses in 1997. This was the only year we had data on licensing. The number of licenses issued has been falling over time. See Mobarak and Purbasari (2005).

[33] In column 2, both the tariff terms are jointly significant, with a p-value $= 0.02$.

[34] The results are the same using 2001 weights and Fisher weights. We were unable to get imports at the HS nine-digit, so the import-weighted five-digit ISIC tariffs are constructed by first taking the simple mean of the HS 9-digit to HS 6-digit, then weighting the HS 6-digit tariffs by the import shares.

Table 7—Alternative Tariffs

Dependent variable: ln(TFP$_{it}$)

	Three-digit tariffs		Three-digit tariffs –no liquor		Five-digit tariffs –no liquor	Five-digit tariffs –import weighted		I/O code tariffs with 1995 cost shares	I/O code tariffs with 1998 cost shares
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Output tariff$_t^k$	−0.039	−0.007	−0.531***	−0.668***	−0.128***	−0.046***	0.003	0.002	0.009
	(0.038)	(0.044)	(0.053)	(0.066)	(0.042)	(0.003)	(0.018)	(0.023)	(0.027)
Input tariff$_t^k$		−0.205**		0.399***	−0.426***		−0.062***	−0.507***	−0.539***
		(0.104)		(0.110)	(0.063)		(0.023)	(0.048)	(0.067)
Input tariff$_t^k$ × FM$_{it}$							−0.946***	−0.329***	−0.420***
							(0.075)	(0.050)	(0.059)
FM$_{it}$ = 1 if import share > 0		−0.007		−0.005	−0.006		0.083***	0.023***	0.024***
		(0.007)		(0.007)	(0.007)		(0.010)	(0.008)	(0.009)
FX$_{it}$ = 1 if export share > 0		−0.013***		−0.013***	−0.013***		−0.011**	−0.010**	−0.010**
		(0.005)		(0.005)	(0.005)		(0.005)	(0.005)	(0.005)
FF$_{it}$ = 1 if foreign share ≥ 0.1		0.070***		0.075***	0.074***		0.069***	0.070***	0.071***
		(0.017)		(0.017)	(0.017)		(0.017)	(0.017)	(0.017)
Herfindahl index^k_t		−0.075***		−0.073***	−0.079***		−0.083***	−0.072***	−0.061***
		(0.021)		(0.021)	(0.021)		(0.021)	(0.021)	(0.021)
Exit$_{it}$ = 1 if firm exits in t + 1		−0.042***		−0.042***	−0.042***		−0.040***	−0.041***	−0.042***
		(0.004)		(0.004)	(0.004)		(0.004)	(0.004)	(0.004)
Island × year effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	170,741	170,741	168,640	168,640	168,640	170,741	170,741	170,741	170,741
R-squared	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If, instead, error terms were corrected for clustering at the industry-year level, all significant variables remain significant with p-values < 0.05, except that *output tariff* in column 5 becomes insignificant, *input tariff* in columns 2 and 7 becomes insignificant, *Herfindahl index* in columns 2–5 and 8–9 becomes insignificant, and *Herfindahl index* in column 7 is significant only at the 10 percent level.
*** Significant at, or below, 1 percent.
** Significant at, or below, 5 percent.
* Significant at, or below, 10 percent.

The input tariffs are calculated as a weighted average of the output tariffs using the input cost shares in 1998. The year 1998 was chosen because it was the only year available where we had highly disaggregated data on inputs. There might be a concern that these input shares are not representative of the whole sample period because of the Asian crisis. To check this, we reconstruct the input tariffs using cost shares from the 1995 input/output tables. The disadvantage of using these data is that they are more aggregated (with only 90 manufacturing sectors), but the advantage is that the input shares are calculated for a year before the Asian crisis. To ensure that any differences with our previous results are not driven by the higher level of aggregation, we also recalculated the input tariffs using cost shares from 1998 with the same input/output codes for comparison. From columns 8 and 9, we can see that the results are almost identical using the 1995 and 1998 cost shares, although the magnitude of the input tariff interacted with importing firms is lower using this higher level of aggregation of industry codes.

D. *Asian Crisis*

There may be concern that the key results are affected by the Asian financial crisis, which started in August 1997, given the large currency depreciations and high levels of inflation during our sample period. One way to rule this out is to reestimate the equations using data only up to 1996, thus avoiding the Asian crisis period altogether. The *TFP* estimates in columns 1 and 2 of Table 8 are also estimated with data only up to 1996, to ensure that the production coefficients are not influenced by the Asian crisis data. We see from column 1 that the coefficients on output tariffs and the input tariff interacted with importing firms are now both insignificant, though the coefficient on input tariff remains negative and significant. For the shorter sample period, the lower coefficients and reduced significance might be explained by the reduced variation in tariffs, since most of the trade liberalization began in 1995. Nevertheless, if there is any differential effect between importers and nonimporters in the period before 1997, this is likely to occur in industries that comprise a large number of importing firms. Thus, we select two-digit industries with more than 40 percent of firms importing their inputs during this period, and construct a dummy equal to one for importing firms within these two-digit industries, which include the chemical, metal, machinery, and toy industries.[35] Interacting this dummy with *input tariff* × *FM* in column 2, we see that this coefficient is indeed negative and significant, equal to −0.7, which is very close to the point estimates for importing firms in Table 4.

In column 3 of Table 8, we return to the full sample, but we interact the output tariff and the input tariff variables with a crisis dummy equal to one for the years 1997 and 1998. We see that the key results are robust; the size of the coefficients on the output and input tariffs remains unchanged. Looking at the crisis interaction terms, we note that the interaction term on output tariffs is insignificant, whereas the coefficient on the interactive *input tariff* × *FM* variable is positive and significant, indicating that there are some offsetting effects during the Asian crisis for importers. This may not be surprising, given the price hikes of imported inputs following the large depreciation during that period. Nevertheless, the net effect of reducing input tariffs is still positive for importers, even during the crisis period.

The large currency depreciations that Indonesia experienced during the Asian crisis could affect measured productivity without any changes to efficiency, especially since our deflators are at the industry level rather than at the firm level. To ensure that this is not all that is being picked up in our estimates, in column 4, we interact trade-weighted exchange rates with importers and exporters. Although the island-year fixed effects pick up changes in the annual exchange rate, the depreciation should have differential effects on importers and exporters. Both of these coefficients turn out to be negative and significant. If exporters draw on inventories to meet demand during times of large depreciations, this is likely to show up as an increase in *TFP* because the firm would enjoy additional sales revenues without any corresponding increase in input costs. The negative coefficient on the exchange rate interacted with importers may reflect deviations in firm-level prices relative to the industry deflator. If importers in differentiated industries pass on some of the increase in imported input prices to consumers, the output industry deflator increases less than the individual firm price, showing an increase in *TFP*; conversely, for domestic producers, the industry deflator increases by more than their actual price, showing a decrease in *TFP*.[36]

We see that the coefficient on output tariffs is not changed by the inclusion of exchange rates; the coefficient on the interactive input tariff variable falls in absolute value, however, from −0.86 to −0.26 (column 4). This suggests that some of the benefits of reducing input tariffs in the previous tables were in fact due to exchange rate movements. Notably, even after controlling for the trade-weighted exchange rates, there is still an additional productivity gain to importers due to the fall in input tariffs. A fall in input tariffs by 10 percentage points increases productivity by 6 percent, after controlling for the differential effect of exchange rates on importers and exporters. In column 5, we include the exchange rates and the interactive crisis terms

[35] These are ISIC two-digit industries 35, 37, 38, and 39. These industries account for 25 percent of the observations and half of the importing firms. The metals industry, ISIC 37, comprises the largest share of importers, equal to 54 percent.

[36] The same is not true for input prices because domestic and imported inputs are deflated with separate deflators.

TABLE 8—ASIAN FINANCIAL CRISIS

Dependent variable: $\ln(\text{TFP}_{it})$	1991–1996 Pre–Asian crisis		1991–2001 Full sample			
	(1)	(2)	(3)	(4)	(5)	(6)[a]
Output tariff_t^k	−0.015	−0.018	−0.103**	−0.107**	−0.114***	−0.120***
	(0.044)	(0.044)	(0.042)	(0.043)	(0.043)	(0.043)
Input tariff_t^k	−0.361***	−0.369***	−0.314***	−0.334***	−0.328***	−0.326***
	(0.119)	(0.118)	(0.062)	(0.062)	(0.062)	(0.062)
Input $\text{tariff}_t^k \times \text{FM}_{it}$	−0.118	−0.057	−0.875***	−0.262**	−0.261**	−0.477**
	(0.109)	(0.109)	(0.086)	(0.108)	(0.108)	(0.225)
Input $\text{tariff}_t^k \times \text{FM}_{it} \times \text{high FM}^k$		−0.693***				
		(0.130)				
$\text{FM}_{it} = 1$ if import share > 0	−0.010	0.012	0.085***	−0.024	−0.024	−0.023
	(0.017)	(0.018)	(0.012)	(0.018)	(0.018)	(0.038)
$\text{FX}_{it} = 1$ if export share > 0	0.023***	0.023***	−0.010**	−0.026***	−0.026***	−0.035***
	(0.007)	(0.007)	(0.005)	(0.007)	(0.007)	(0.009)
$\text{FF}_{it} = 1$ if foreign share ≥ 0.1	0.061***	0.062***	0.070***	0.068***	0.068***	0.071***
	(0.021)	(0.021)	(0.017)	(0.017)	(0.017)	(0.023)
$\ln(\text{TWI}_t^k) \times \text{FM}_{it}$				−0.066***	−0.065***	−0.134***
				(0.009)	(0.009)	(0.017)
$\ln(\text{TWI}_t^k) \times \text{FX}_{it}$				−0.025***	−0.025***	−0.039***
				(0.007)	(0.007)	(0.008)
Output $\text{tariff}_t^k \times \text{crisis dummy}_t$			0.031		0.028	0.030
			(0.040)		(0.040)	(0.040)
Input $\text{tariff}_t^k \times \text{crisis dummy}_t$			0.009		0.043	0.026
			(0.079)		(0.079)	(0.079)
Input $\text{tariff}_t^k \times \text{FM}_{it} \times \text{crisis dummy}_t$			0.178***		0.048	0.146
			(0.067)		(0.069)	(0.112)
Herfindahl index_t^k	−0.011	−0.019	−0.080***	−0.078***	−0.076***	−0.081***
	(0.024)	(0.024)	(0.021)	(0.021)	(0.021)	(0.021)
$\text{Exit}_{it} = 1$ if firm exits in $t + 1$	−0.021***	−0.021***	−0.040***	−0.038***	−0.038***	−0.039***
	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)
Year fixed effects	yes	yes	yes	yes	yes	yes
Observations	88,442	88,442	170,741	170,741	170,741	170,741
R-squared	0.87	0.87	0.80	0.80	0.80	0.80

Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If, instead, error terms were corrected for clustering at the industry-year level, all significant variables remain significant with p-values < 0.05, except that *output tariff* in columns 3–6 becomes insignificant, *input tariff* in columns 1 and 2 becomes insignificant, *input tariff × FM × crisis* in column 3 becomes insignificant, *Herfindahl index* in columns 3–5 becomes insignificant, and *Herfindahl index* in column 6 is significant only at the 10 percent level.

[a] In column 6, *FM* is import share, *FX* is export share, and *FF* is foreign share.

*** Significant at, or below, 1 percent.

** Significant at, or below, 5 percent.

* Significant at, or below, 10 percent.

with tariffs. After controlling for the exchange rates, all of the interactive crisis terms become insignificant. In column 6, we show that the results in column 5 carry over when we interact input tariffs with import share rather than with an importer dummy.

In sum, Table 8 suggests that the size of the effect of reducing input tariffs is somewhat lower after taking account of the Asian crisis, yet there remains a significant and sizable effect.

E. *Alternative Econometric Specifications*

So far, all the estimations have been on levels with firm and island-year fixed effects. In Table 9, we experiment with alternative econometric specifications, and continue to control for the exchange rate interacted with importers and exporters. In columns 1 and 2, the dependent variable is log *TFP* and the specifications include five-digit industry fixed effects instead of firm fixed effects. Input tariffs are interacted with *FM* in all of the specifications in Table 9.[37] We see that the results are generally consistent with the firm fixed effect model in Table 8.

In columns 3 and 4 of Table 9, we include all variables in two-period differences. This differencing wipes out unobserved firm heterogeneity. In column 4, once we add input tariffs, the coefficient on output tariffs becomes insignificant. The size of the coefficient on the input tariff interacted with *FM* is now larger compared to the levels equation with plant fixed effects in column 5 of Table 8. Taking longer differences over five periods, in columns 5 and 6, produces similar sized coefficients on the tariff variables as with the two-period differences. In column 5, we include only final goods tariffs, and the coefficient is equal to −0.2, which is close to our original estimate in the fixed effects model. We add the input tariffs in column 6, and once again the coefficient on output tariffs is more than halved. In columns 7 and 8, we include all variables in nine-period differences.[38] As well as reducing measurement error, this has the advantage of avoiding serial correlation, since there is now only one observation per firm. The size of the output tariff is now much higher than in previous specifications, indicating that a 10 percentage point fall in output tariffs increases productivity by 3 percent. The size of the coefficient on *input tariff* × *FM* is even higher in the long difference specification than with the two- and five-period differences, showing that a 10 percentage point fall in input tariffs is associated with a 10 percent increase for importing firms. The same general pattern persists across all of these specifications, with importing firms enjoying the largest productivity gains from tariff reform.

F. *Endogeneity*

Finally, we address the issue of the potential endogeneity of tariffs. It could be argued that firms in low-productivity industries lobby for protection, which would lead to reverse causality, or that governments pick “winners” to protect against foreign competition, so it is unclear which way the bias, if any, would go. It is generally difficult to find valid instruments for tariffs, and, in the case of Indonesia, in a firm fixed-effects model it is unclear whether there is in fact a serious endogeneity issue. Nevertheless, for the sake of completeness, we address this potential concern in Table 10, by instrumenting for output tariffs, input tariffs, and the input tariff interacted with an indicator for importing firms. All of the specifications are for the five-period difference model, as it is easier to find instruments for changes in tariffs than for levels.

The set of instruments includes the 1991 levels of output tariffs, the 1991 levels of input tariffs, an interaction between the 1991 input tariffs and a firm-level indicator equal to one if the firm was an importer in all years, a dummy indicator for product codes that comprised at least one nine-digit HS code that was excluded from the commitment to reduce bound tariffs to 40 percent, and the proportion of skilled workers at the five-digit industry level. In all the specifications, the

[37] Interacting the input tariffs with import shares produces the same results.

[38] These variables are constructed for 2000 minus 1991. We use nine-period differences instead of ten-period differences because there are more firms in our sample in 2000 than 2001. Even though a larger number of firms existed in 2001, we could not include all of them in our sample because the statistical authorities introduced new firm codes, which made it difficult to match some of the firms with the previous firm codes.

TABLE 9—ALTERNATIVE ECONOMETRIC SPECIFICATIONS

Dependent variable: ln(TFP_{it})	Levels		Two-period difference		Five-period difference		Nine-period difference	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔOutput tariff$_t^k$	−0.224***	−0.127***	−0.140***	−0.014	−0.204***	−0.085*	−0.386***	−0.302***
	(0.032)	(0.041)	(0.027)	(0.036)	(0.040)	(0.050)	(0.072)	(0.096)
ΔInput tariff$_t^k$		−0.279***		−0.336***		−0.365***		−0.158
		(0.059)		(0.054)		(0.071)		(0.145)
ΔInput tariff$_t^k \times FM_{i,t-j}$		−0.489***		−0.515***		−0.455***		−0.902**
		(0.100)		(0.139)		(0.174)		(0.411)
ΔFM_{it}	0.019**	0.092***	0.000	0.003	0.028***	0.029***	0.038	0.038
	(0.007)	(0.017)	(0.007)	(0.007)	(0.010)	(0.010)	(0.024)	(0.024)
ΔFX_{it}	0.066***	0.068***	0.012**	0.011**	0.026***	0.023***	0.026	0.024
	(0.007)	(0.007)	(0.005)	(0.005)	(0.009)	(0.009)	(0.024)	(0.024)
ΔFF_{it}	0.247***	0.248***	0.079***	0.080***	0.068***	0.069***	0.117**	0.118**
	(0.011)	(0.011)	(0.016)	(0.016)	(0.024)	(0.024)	(0.057)	(0.057)
$\Delta\ln(TWI_t^k) \times FM_{i,t-j}$	−0.096***	−0.068***	−0.067***	−0.049***	−0.080***	−0.055***	−0.065***	−0.009
	(0.007)	(0.009)	(0.008)	(0.010)	(0.008)	(0.012)	(0.014)	(0.029)
$\Delta\ln(TWI_t^k) \times FX_{i,t-j}$	−0.004	−0.002	−0.075***	−0.072***	−0.064***	−0.060***	−0.037**	−0.035**
	(0.007)	(0.007)	(0.009)	(0.009)	(0.009)	(0.009)	(0.018)	(0.018)
ΔHerfindahl index$_t^k$	−0.132***	−0.139***	−0.002	0.000	−0.195***	−0.198***	0.071	0.048
	(0.023)	(0.023)	(0.019)	(0.019)	(0.030)	(0.030)	(0.063)	(0.066)
$Exit_{it} = 1$ if firm exits in $t + 1$	−0.081***	−0.081***						
	(0.005)	(0.005)						
Island × year effects	yes	yes	yes	yes	yes	yes	island effects	
Industry fixed effects	yes	yes	no	no	no	no	no	no
Firm fixed effects	no	no	yes	yes	yes	yes	no	no
Observations	170,741	170,741	111,107	111,107	56,320	56,320	6,089	6,089
R-squared	0.55	0.55	0.01	0.01	0.02	0.02	0.01	0.02

Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If, instead, error terms were corrected for clustering at the industry-year level, all significant variables remain significant with p-values < 0.05, except *output tariff* in columns 2 and 6 becomes insignificant and *input tariff* in column 6 is significant only at the 10 percent level.
*** Significant at, or below, 1 percent.
** Significant at, or below, 5 percent.
* Significant at, or below, 10 percent.

instruments provide a good fit in the first stage,[39] and comfortably pass the overidentification tests with a p-value ranging from 0.14 to 0.72.

In column 1, where the output tariff is the only endogenous variable included, the size of its coefficient is much higher in absolute value than it was with OLS, equal to −0.75. In column 2, where we include input tariffs, the size of the coefficient on output tariffs falls by a smaller amount than with OLS, to −0.66. In column 3, we interact the change in input tariffs with a firm-level indicator, $FM_{i,t-5}$, equal to one if the firm imported any of its imports in period $t - 5$. These estimates suggest that all

[39] For specifications with more than one endogenous variable, the Cragg-Donald statistic, with a χ^2 distribution, is included to check for weak instruments. In all of the specifications, the Cragg-Donald statistic is well above the critical values listed in Table 1 of James H. Stock and Motohiro Yogo (2005).

the benefits from reducing input tariffs accrue to importers; the coefficient on input tariffs is insignificant but the input tariff interacted with importing firms is significant and equal to −1.3, which implies that a 10 percentage point fall in input tariffs increases productivity for importers by 13 percent, and there is no productivity improvement for nonimporters. This contrasts with the OLS results in column 6 of Table 9, which show there is also a gain for nonimporters. The overall gain to importing firms, however, was only slightly lower with OLS estimates in Table 9, at 10 percent. Including controls for exporters and foreign firms, in column 4, does not affect the results. In columns 5 and 6, we include actual shares of importers, exporters, and foreign firms, rather than dummy indicators. In column 5, the instruments are the same as in the previous column. We experiment with a variation on the instrument set in column 6, by interacting the input tariff with a firm-level indicator equal to one if the firm imported at the beginning of the sample, in 1991. This reduces the sample size considerably and increases the size of the coefficient on importers slightly.

The two-stage least squares results suggest that the OLS coefficients are underestimated. In all cases, the coefficient on output tariff is much higher under two-stage least squares, ranging from 0.63 to 0.75. The effect for importing firms is also higher in some specifications, with coefficients ranging between 1.0 and 1.3 (compared with a similar specification using OLS estimates, equal to 0.8, in column 6 of Table 9); and the effect of input tariffs on nonimporting firms is now insignificant (compared with an OLS estimate of 0.3). Although the magnitudes are somewhat different than with OLS, the key message remains. That is, reducing output and input tariffs increases productivity, but the largest gains arise from reducing input tariffs and these accrue to importing firms.

V. Conclusions

This study is one of the first to estimate the effects of reducing input tariffs on firm productivity, and it is the only one to isolate the effect on importing firms from other firms. Our analysis has produced important new findings. We show that the effect of reducing input tariffs significantly increases productivity, and that this effect is much higher than reducing output tariffs. A 10 percentage point fall in input tariffs leads to a productivity gain of 12 percent for firms that import their inputs, at least twice as high as any gains from reducing output tariffs; the productivity estimates from reducing output tariffs range between 1 and 6 percent. Further, our analysis suggests that excluding input tariffs could result in an omitted variable bias problem, overestimating the competition effect arising from lower output tariffs. Once we included input tariffs, the coefficient on output tariffs fell significantly; in some specifications, the size of the coefficient on output tariffs fell by more than half.

The finding that importers enjoy large gains from lower input tariffs is robust across all different specifications. We followed the standard way of estimating total factor productivity, using the Olley-Pakes (1996) methodology, which corrects for the simultaneity of input choices and exit. In addition, we corrected for the simultaneity between the decision to import intermediate inputs and productivity shocks, and we deflated the share of imported inputs by import price deflators and took account of the Asian crisis. We found that the results were not sensitive to the way we measured productivity, including *TFP* measures from OLS estimates with Cobb-Douglas and translog technology, as well as labor productivity. But, the conventional problem of separating physical productivity from mark-ups for firms in imperfectly competitive industries remains. To address this, we allowed for a differential effect for importers in concentrated industries and we found that importers enjoyed the same productivity gains in both concentrated and competitive industries. Further, whether firms switched their main industry group did not affect the size of the productivity gains.

We hypothesized that if the productivity gains were larger for importing firms compared to nonimporters, this should reflect direct benefits arising from higher-quality foreign inputs, more differentiated varieties of inputs, and/or learning effects. Although our results are consistent with this hypothesis, we cannot say for certain which, if any, of these channels is causing the increased productivity until we find suitable measures of these different channels. This is an area for future research.

TABLE 10—ENDOGENEITY

Dependent variable: $\ln(\text{TFP}_{i,t})-\ln(\text{TFP}_{i,t-5})$ All variables in 5 period difference	(1)	(2)	(3)	(4)	(5)	(6)
ΔOutput tariff$_t^k$	−0.754*** (0.067)	−0.657*** (0.071)	−0.644*** (0.071)	−0.629*** (0.071)	−0.638*** (0.072)	−0.668*** (0.082)
ΔInput tariff$_t^k$		−0.326*** (0.106)	−0.099 (0.123)	−0.106 (0.123)	−0.171 (0.115)	−0.159 (0.131)
ΔInput tariff$_t^k$ $\times$ FM$_{i,t-5}$			−1.274*** (0.415)	−1.324*** (0.413)		
ΔInput tariff$_t^k$ $\times$ import share$_{i,t-5}$					−1.942*** (0.724)	−2.211*** (0.814)
ΔFM$_{it}$			0.040*** (0.010)	0.038*** (0.010)		
ΔImport share$_{it}$					0.118*** (0.021)	0.097*** (0.025)
ΔFX$_{it}$				0.020** (0.009)		
ΔExport share$_{it}$					0.032*** (0.011)	0.033** (0.014)
ΔFF$_{it}$				0.070*** (0.024)		
ΔForeign share$_{it}$					0.001*** (0.000)	0.001 (0.000)
$\Delta\ln(\text{TWI}_t^k)$ $\times$ FM$_{i,t-5}$	−0.078*** (0.007)	−0.076*** (0.007)	−0.025 (0.022)	−0.021 (0.022)		
$\Delta\ln(\text{TWI}_t^k)$ $\times$ import share$_{i,t-5}$					−0.078** (0.039)	−0.029 (0.044)
$\Delta\ln(\text{TWI}_t^k)$ $\times$ FX$_{i,t-5}$	−0.046*** (0.007)	−0.044*** (0.007)	−0.042*** (0.007)	−0.053*** (0.009)		
$\Delta\ln(\text{TWI}_t^k)$ $\times$ export share$_{i,t-5}$					−0.069*** (0.011)	−0.070*** (0.014)
ΔHerfindahl index$_t^k$				−0.209*** (0.030)	−0.210*** (0.030)	−0.185*** (0.034)
Island *x* year effects	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes
Weak instruments	F(3)=5712.42	$\chi^2(4)$=6528.68	$\chi^2(6)$=2081.14	$\chi^2(6)$=2082.70	$\chi^2(6)$=2196.36	$\chi^2(6)$=1609.52
Overidentification	2.80	2.08	2.80	2.78	1.36	5.48
Hansen J statistic	0.25	0.35	0.43	0.43	0.72	0.14
Observations	56,320	56,320	56,320	56,320	56,320	41,676

Notes: Robust standard errors corrected for clustering at the firm level in parentheses. If, instead, error terms were corrected for clustering at the industry/year level, all significant variables remain significant with p-values <0.05, except input tariff in column 2 becomes insignificant and *TWI* $\times$ *import share* in column 5 is significant only at the 10 percent level. Instruments in column (1) *output tariff*$_{1991}$, *exclusion dummy* = 1 if product excluded from commitment to reduce bound tariffs to 40 percent, *proportion of low-skilled workers*$_t^k$; (2) as in column 1, plus *input tariff*$^k_{1991}$; (3)–(5) as in column 2, plus *input tariff*$^k_{1991}$ if firm imported every year in the sample and a dummy if firm imported every year in the sample; (6) as in column 2, plus *input tariff*$^k_{1991}$ if the firm imported in 1991 and a dummy if the firm imported in 1991.

*** Significant at, or below, 1 percent.
** Significant at, or below, 5 percent.
* Significant at, or below, 10 percent.

Appendix: Olley-Pakes Methodology

The Olley-Pakes methodology takes into account that the error term in equation (2), e_{it}, has two components, a white noise component, η_{it}, and a time-varying productivity shock, ω_{it}. A well-known problem in the estimation of production functions is the correlation between unobservable productivity shocks, ω_{it}, and the input factors that are chosen by the firm, which yield inconsistent estimates under OLS. A second endogeneity problem arises due to sample selection. Firms leave the market when productivity falls below a certain threshold, and thus the surviving firms will have ω_{it} from a selected sample, which has an effect on the inputs used. The Olley-Pakes approach is based on dynamic optimization of firms, where it is assumed that unobserved productivity, ω_{it}, follows a first-order Markov process and capital is accumulated by firms through a deterministic dynamic investment process. Profit maximization yields an investment demand function that depends on two state variables, capital and productivity, $I_{it} = i(k_{it},\omega_{it},\Delta_t) = i_t(k_{it},\omega_{it})$, where Δ_t represents the economic environment such as industry and market characteristics common to all firms operating in the industry. Pakes (1994) specifies the conditions under which the investment function is monotonically increasing in productivity, which makes it possible to invert the investment function and gives an expression for productivity as a function of capital and investment.

We modify the Olley-Pakes framework by incorporating the decision to engage in international trade. When there are sunk costs to enter international markets and when it is the more productive firms that typically engage in international trade, as suggested by a number of recent papers (see, for example, Melitz 2003), treating the decision to import or to export as exogenous does not seem appropriate. We therefore follow the approach proposed by Kasahara and Rodrigue (2005), Van Biesebroeck (2005), and De Loecker (2006), and modify the Olley-Pakes model by treating the import and export decisions as additional state variables. It is assumed that the decisions to import and to export are chosen by the firm in period $t - 1$, just as the decision to invest in new capital is taken in period $t - 1$. This implies that the investment demand function becomes a function of four state variables, capital, productivity, import status (FM), and export status (FX), $I_{it} = i_t(k_{it}, \omega_{it}, FM_{it}, FX_{it})$.[40] In addition, to take account of the Asian crisis, we make the investment function depend on three sub-periods: 1991 to 1996; 1997 to 1998; and 1999 to 2001. Inverting the investment function gives an expression for productivity as a function of the state variables, capital, the decision to import, the decision to export, and investment,

$$\text{(A1)} \qquad \omega_{it} = h_t(k_{it}, I_{it}, FM_{it}, FX_{it}).$$

We assume that the adjusted investment function is still increasing in productivity. Van Biesebroeck (2005) discusses the conditions under which this assumption holds.[41]

By substituting equation (A1) into (2), we can recover consistent estimates of the variable input coefficients using nonparametric techniques,

$$\text{(A2)} \qquad y_{it} = \beta_l l_{it} + \beta_m m_{it} + \phi_{it}\ (I_{it}, k_{it}, FM_{it}, FX_{it}) + \eta_{it}\,.$$

In the first step we obtain consistent estimates of β_l and β_m. We use a series estimator with a fourth-order polynomial in investment, capital, the import and export status, and three time dummies that capture the period during the Asian crisis, and before and after the crisis. In the second step of the estimation procedure, the probability that a firm exits from the sample is determined by the probability that the end-of-period productivity falls below an exit threshold. We use the same fourth-order polynomial defined as before to estimate this probability. In the third step, the coefficients of the state variables are estimated using nonlinear least squares.

[40] This implies that just like there is a deterministic investment rule that describes the evolution of capital, there also exists a decision rule that describes the change in export and import status.

[41] In particular, the marginal return to exporting (importing) has to be increasing in productivity. There must be sunk costs to become an exporter (importer), which guarantees that the cost savings for an exporter (importer) that quits the export (import) market are smaller than the cost a nonexporter (nonimporter) has to incur to enter the export (import) market. Finally, there are no costs incurred when the export (import) status does not change.

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